

POLLUTION HEALTH SIGNIFICANCE OF POLYMER RESIN ON ARTISANS IN A DEVELOPING COUNTRY SETTING

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ABSTRACT

Use of polymer resin (a mixture of plastic resin and catalyst) for lamination of wooden frame of enlarged photographs exposes lamination artisans in developing countries to sensitivities to the toxic resin, especially as the artisans fail to comply with the safety measures recommended by manufacturers. This study was aimed at investigating the pollution health significance of the polymer resin by determining its acute toxicity (rat, oral). The modified acute toxicity test method of Miller and Tainter was used. Results showed that the LD₅₀ of polymer resin was 1,895 mlkg⁻¹, which fell within the literature range of toxic and lethal values, and therefore, poses a serious threat to the health of artisans. It is recommended that manufacturers of polymer resin, civil society organisations and the government should adopt persuasive approach to enlighten the artisans on the need to toe the precautionary path and for

strict compliance with manufacturer's safety measures for handling polymer resin. Policymakers should also factor in the situation.

Keywords: *Polymer resin sensitivity; Photography frame lamination; Artisans*

INTRODUCTION

Technology integration is growing in many developing African countries. An area that has witnessed rapid transformation is the technology for the presentation of enlarged photographs for display. Formerly, uncovered enlarged pictures were hung on the wall in homes and offices. The edges of the photographs soon folded. The next technology gave it a wooden frame to hold the edges in shape. Over time, however, the hanging frame became blurred and unsightly with layers of dust gathered. The next turn of technology covered it with glass to prevent dust. An improvement on this technology replaced the wood with aluminum frame for both beauty and longer lifespan. But, the glass soon got broken, with movement and time. The latest technology laminates the picture on a wooden frame by use of polymer resin. The advantages are enormous, since polymer resin coating is glossy, unbreakable, fade-proof, water-resistant, more fanciful and more durable (Eneh and Mba, 2012a; Eneh et al, 2012a; Eneh et al, 2012b).

Resin Supplies (Resin.supplis.co.uk, 2011) reported that polyester resin is the most common castable resin. It is a catalytic system to which is added a small amount of methylbutylketone (MEK) peroxide to accelerate the polymerization of the liquid resin (which would eventually cure on its own, particularly if left in the sun). Curing time can be controlled by varying the amount of catalyst added.

Polymer resin is a clear liquid plastic product made up of a liquid plastic resin and a liquid catalyst. The two parts are mixed, usually in equal proportions, and are thoroughly homogenised. The catalyst activates the liquid plastic resin to begin the hardening or curing process. The mixture is poured over the surface of the photograph enlargement frame that the lamination artisan wishes to coat (Wisegeek.com, 2010).

The ugly side of polymer resin is its pollution. Polymer resin emits potentially toxic gas when it cures. The catalyst is toxic and can quickly cause eye damage. Sensitivities to resin include itchiness, rashes that may go cracky with bleeding in neglected cases, constricted throat and windpipe and lungs from resin fumes, liver problems, welts between fingers and toes first and then elsewhere blood is close to the surface, streaming eyes/nose that become red on dust exposure. Contact dermatitis is by far the most common resin sensitivity. It is caused mostly by skin exposure to the hardener, but also to a lesser extent to the resin. Most resin hardeners are proven carcinogens. Resin interferes with DNA. It is persistent and exposure may not manifest in symptoms until months or even years later (Wisegeek.com, 2010).

Therefore, precautionary measures for working with polymer resin are advisable. Manufacturers print these safety measures on product packages. But, artisans in developing countries often fail to comply with them because of high level of ignorance and illiteracy, get-rich-quick mentality, and weak environmental regulatory infrastructure (Eneh, 2011).

Rogers (1995) posited that potential adopters of a technology pass through the 5-stage technology diffusion process involving knowledge (learning about the technology), persuasion (being persuaded about the value of the technology), decision (deciding to adopt the technology), implementation (implementing the technology), and confirmation (reaffirming or rejecting the decision to adopt the technology). Yet,

artisans in developing countries often stop at learning only the occupational skills with little or no attention paid to the health and environmental hazards and the needed safety measures, moreso where chronic toxicity is the issue. The knowledge acquired is, therefore, insufficient to form the foundation for the subsequent persuasion about the value of the technology, decision to adopt the technology, implementation of the technology acquisition, and reaffirmation of the value of the technology.

That everyone can be sensitized to polymer resin (Wisegeek.com, 2010) is cause for worry. There are separate literature reports on the toxicity of plastic resin and the catalyst. But, the literature gap on the toxicity of polymer resin (mixture of both the plastic resin and the catalyst) on the artisans that apply it needs to be addressed. To this end, this study aimed at investigating the pollution health significance of polymer resin. The specific objective was to determine the value of lethal dose 50 (LD₅₀) of polymer resin with rats (oral). The study assumed that a dose of polymer resin is not significantly related to the number of deaths of rats to which it had been acutely exposed by oral administration.

The report of the empirical study will be a reference point for further researches and policy-making. Another significance of the study lies in its identification with Sustainable Chemistry, which is a philosophy of chemical research and engineering that encourages the design of products and processes that minimize the use and generation of hazardous substances. It is a highly effective approach to pollution prevention because it applies innovative scientific solutions to real-world environmental situations (US EPA, 2010).

MATERIALS AND METHODS

Materials

Tween 80 (inert solvent) (Ema et al., 2007; Chou et al., 2005; Steele et al, 2005; Goff, 1997; Williams et al, 1997; Gajdova et al, 1993; Oser and Oser, 1956 a,b) was obtained from the laboratory of the Department of Pharmacology and Toxicology, Faculty of Pharmaceutical Sciences, University of Nigeria, Nsukka. The plastic resin used was a mixture of polyester resin, styrene monomer, an initiator, and a promoter. It was cured by adding methyl ethyl ketone (MEK) peroxide, which reacted with the promoter to create heat, which along with the initiator, caused an exothermic reaction that cross-linked the resin. Both the plastic resin and the catalyst were obtained from dealers, who sold to the lamination artisans in Enugu, Nigeria.

Methods

The Randhawa (2009) modified version of the Miller and Tainter (1944) method for acute toxicity test was used. In the preliminary studies carried out to determine the dose range to be used in the acute toxicity tests, the animals in groups of close weight ranges (n=20 for each group) were separately exposed to doses of 100, 300, 550, 800, 1200, 1800, 2700, 4000, 6000 and 9000 mlkg⁻¹ of polymer resin in inert solvent (Tween 80) for 24h. The control set was exposed to the solvent without the resin. After oral administration, the animals were observed regularly and mortality recorded at 3h, 6h, 12h and 24h. Subsequently, a series of five (5) doses between the dose that killed a few or none of the animals and all or most of the animals were selected and used for acute toxicity test. The percentage of animals that had died at each dose level was then

transformed to probit. The probit for 100% was corrected, using the formula (Randhawa, 2009):

$$\text{Probit for 100\%} = 100 \left(n - \frac{0.25}{n} \right)$$

The probit values (y) were plotted against log doses (x). The log dose corresponding to probit 5 was traced and the anti-log noted as the value for LD₅₀, which killed 50% of the rats.

Analysis of data

The data were analyzed using the simple linear regression (SLR) technique of the statistical package for social sciences (SPSS). The independent variable (x) was the log dose of the polymer resin, while the dependent variable (y) was the % dead of the experimental animals. SLR also helped to correlate the data and to test the hypothesis.

According to Nwbuokei (2001), SLR technique predicts one interval data dependent variable, y, from another ratio data, independent variable, x:

$$y = a + bx$$

where y is the dependent variable being looked for,

a is the constant of the equation,

b is the coefficient of x, which depicts the dependent variables,

x is the independent variable.

SLR showed correlation statistics (Pearson correlation values and one-tailed significance values), as well as model summary(b) of descriptive statistics (particularly R²). The Pearson correlation value showed the

strength (perfect or otherwise) and nature (positive or otherwise) of the relationship between the dose of polymer resin and the number of the experimental animals killed by the administered dose. One-tailed significance value showed the level of significance of the relationship between the number of the experimental animals killed and the dose of polymer resin administered, as well as the degree of confidence. The R^2 value showed the reliability level of the finding. Thus, the internal validity or otherwise of the finding was established and the null hypothesis was tested.

RESULTS

Table 1 shows the data for acute toxicity test of polymer resin (oral, rat). Polymer resin doses of 1200, 1800, 2700, 4000 and 6000 mlkg^{-1} killed 5, 9, 14, 18 and 20 respectively (rat, oral) within 24h. The plot of probit values of the % dead (y: 4.33, 4.87, 5.52, 6.28 and 7.33) against log doses (x: 3.10, 3.26, 3.43, 3.60 and 3.78) is shown on Fig. 1. The log dose corresponding to probit 5 was 3.28 and its anti-log was 1,895. Therefore, the value of LD_{50} was 1,895 ml/kg (rat, oral) for polymer resin.

Table 1: Acute toxicity test of polymer resin (oral, rat)

Grp	Dose (mlkg^{-1})	Log dose	N	Death rate	% Dead	Corrected %	Probits
1	1,200	3.10	20	5/20	25.00	25.00	4.33
2	1,800	3.26	20	9/20	45.00	45.00	4.87
3	2,700	3.43	20	14/20	70.00	70.00	5.52
4	4,000	3.60	20	18/20	90.00	90.00	6.28
5	6,000	3.78	20	20/20	100.00	98.75	7.33

Source: Laboratory investigations, January 2014

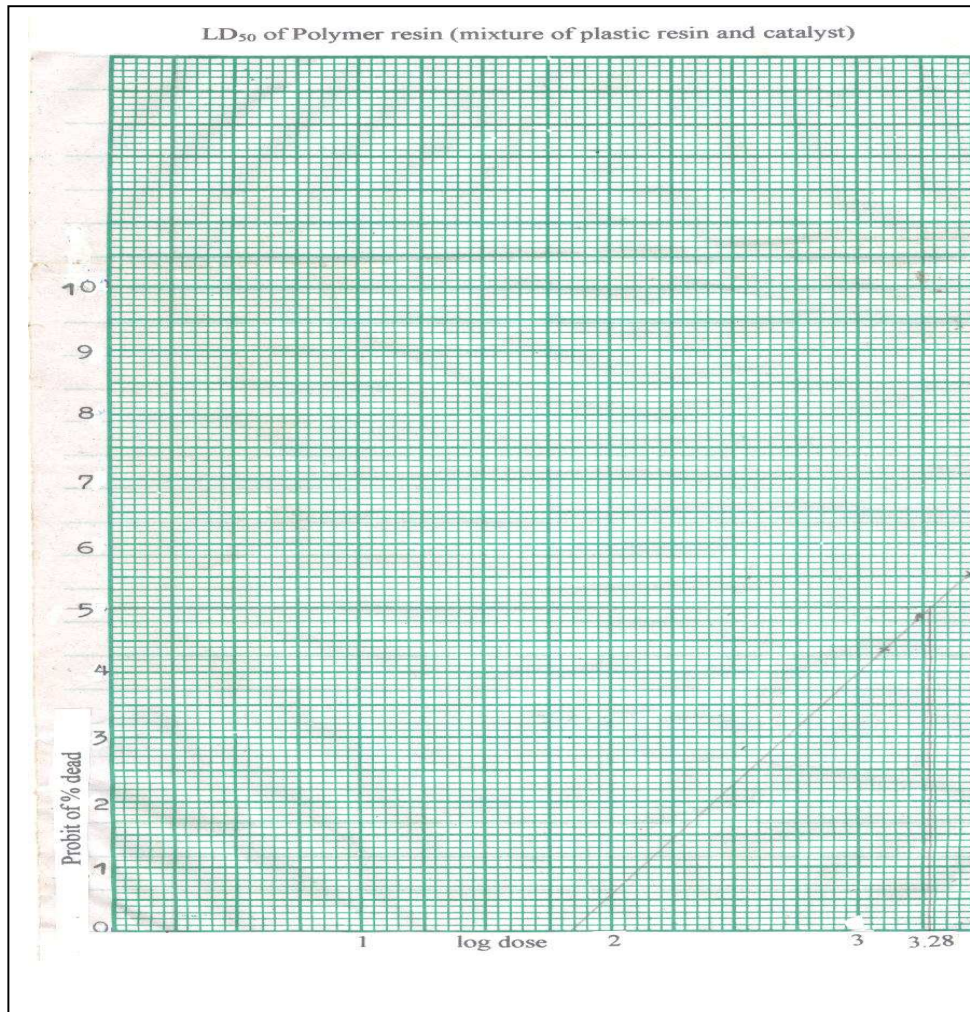


Fig. 1: Plot of log dose against probit of % dead

The SLR analysis of % dead (y: 25%, 45%, 70%, 90% and 100%) against log dose (x: 3.10, 3.26, 3.43, 3.60 and 3.78) showed descriptive statistics, model summary(b), Pearson correlation values, one-tailed significance values, among others (Table 1). The extracted relevant data for correlation, reliability, internal validity and test of hypotheses for the acute toxicity tests of polymer resin are given on Table 2.

Table 2: SLR analyses of % dead and log dose of polymer resin (oral, rat)

Statistics	Parameters	Value
Correlations	Pearson correlation	0.981
	One-tailed significance	0.009
M/summary(b)	R ²	0.962

Source: SLR analysis (SPSS)

At 0.981, the Pearson correlation value between the log dose of polymer resin and % dead of experimental animals showed a perfect positive correlation. The one-tailed significance value of 0.009 showed that the relationship between % dead of experimental animals and log dose of polymer resin is significant at 0.009, with 0.99 degree of confidence. The R² value was high at 0.962, showing high reliability. Therefore, the null hypothesis was rejected in favour of acceptance of the alternative hypothesis: “A dose of polymer resin is significantly related to the number of deaths of rats to which it had been acutely exposed.”

DISCUSSION

The LD₅₀ of 1,895 ml/kg (oral, rat) for the polymer resin is higher than the LD₅₀ of 1,250 ml/kg (oral, rat) and below the LD₅₀ of 2,700-5,600

ml/kg (oral, rat) for MEK reported in the literature (EU-MSDS, 2007; Chevron Philips Chemical Company LP, 2009; Tera.org, 2011). Therefore, the polymer resin (mixture of plastic resin and MEK) is toxic when it cures. This finding is in agreement with the report of the NICNAS (2011) that the LD₅₀ of alkyd resin polymer is >2,000 mg/kg. Epoxy Sensitivity (2011) reported that throat and lungs are affected by polymer resin fumes. Reporting on epoxy safety, Seabase (2011) warns users to be sensible and to use good ventilation, a mask, suitable eye and ear protection. In support of this caution, Resin.supplies.co.uk (2011) submitted that polymer resin should be used only in positively ventilated rooms and with use of rubber gloves, goggles, and protective clothing, adding that skin and nasal irritation and headaches are common effects of short-term exposure to polymer resin. Also, supporting these reports, Usm.maine.edu (2011) opined that all work with uncured polyester resins must be done in a well ventilated area, normally with an exhaust fan running.

This environmental health significance calls for intervention, especially as the artisans ignore it in violation of Rogers (1995) diffusion of innovation (DOI) theory, which states that potential adopters of a technology pass through the 5-stage technology diffusion process involving knowledge, persuasion, decision, implementation, and confirmation or reaffirmation. But, the artisans stop at the acquisition of the occupational skill limited to the knowledge of the application of the toxic chemical in frame lamination, without giving attention to the professional or occupational hazards. This insufficient knowledge forms a defective foundation for the needed persuasion, decision, implementation, and confirmation or reaffirmation for a complete process of innovation adoption of the photography frame lamination technology, which uses the toxic polymer resin.

CONCLUSION

The literature has separate reports on toxicity of plastic resin and its catalyst (MEK peroxide). By determining its acute toxicity, this study discovered that polymer resin (mixture of plastic resin and MEK peroxide) is toxic when it cures. The LD₅₀ (rat, oral) was 1,250 ml/kg (oral, rat), which is a higher toxicity value than LD₅₀ of 2,700-5,600 ml/kg (oral, rat) for MEK reported in the literature.

RECOMMENDATIONS

Therefore, imperative intervention ought to start with sensitizing handlers on the toxicity of polymer resin and the application of precautionary measures usually prescribed according to the law for all toxic chemicals, but which the artisans concerned in the study appear to ignore in violation of Rogers (1995) theory of adoption of technology. Again, the weak environmental regulatory infrastructure in most developing countries panders to this non-compliance. Hence, the situation needs to be brought to the attention of policymakers for a comprehensive policy framework for effective reduction of the adverse health effects arising from the application of polymer resin for the lamination of photographic enlargement frames.

Therefore, to reduce ill-health, death tolls and their consequences among the artisans using polymer resin for photographic frame lamination, it is recommended that:

1. Manufacturers of polymer resin, civil society organisations and the government should adopt persuasive approach to enlighten the artisans on the need for precautionary measures and to comply with them in handling plastic resin, catalyst and polymer resin.

2. Environmental policy-makers should become conscious of the toxicity of polymer resin and come up with policy initiatives to minimise it.
3. Environmental policy regulators should come up with regulatory strategies to minimise the adverse health effects arising from the application of polymer resin for the lamination of photographic enlargement frames.

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